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A DYNAMICAL HYPOTHESIS OF INHERITANCE (II.).

THE egg cannot be isotropic—as follows from observation as well as experiment—in the sense in which the word isotropy is used by physicists of repute. If the egg is a dynamical system it cannot be isotropic or absolutely the same throughout, or along every possible radius from its center, as is proved by its reactions in respect to its surroundings. It may, however, be potentially æolotropic in directions parallel to a certain axis, as experiment has shown by separating the cells that result from segmentation of the egg. Such fragments, if in excess of a certain minimal size, will undergo a larval development of apparently normal character. But this result is fatal to the ordinary corpuscular hypotheses, according to which every future part is represented in the chromosomes by certain hypothetical corpuscular germs. It has, indeed, been shown by Loeb that larval development of portions of an egg can go on whether the divisions be equal or unequal or in any radius. This seems to indicate that an egg is not necessarily isotropic in the undivided state, but that the moment that separation of its mass has occurred there is a readjustment of the relations and potentialities of its molecules simulating that of the original entire egg. The very definition of isotropy, as given by one author (Lord Kelvin), states that it may be assumed only of a spherical mass of matter whose properties are absolutely the same along every one of the infinite number of radii drawn from its center outward, and, as tested by any means whatsoever, shows that such a condition cannot be assumed, on the ground of observation alone, of any known egg. The condition of the egg we must therefore also assume from its known properties to be æolotropic, or different along every one of the

infinite number of radii drawn from its center. When we make this assumption, however, we need not necessarily assume that nucleated fragments that will still develop into larvæ after division of the oösperm, natural or artificial, must be isotropic. They may be æolotropic from the beginning, but in precisely the same way in each case, as a result of the successive cleavages of the germ-mass, by means of planes that cut each other at right angles, as in the diagram Fig. 1, where each of the four segments are precisely alike from the pole a to that of b.

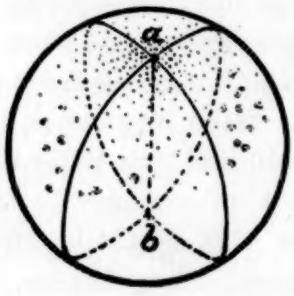

FIG. 1.

The unlikeness of the pole a from b is indicated by the stippling. This unlikeness would manifestly be unimpaired by segmentation of the germ into four quadrants by the first two cleavages, as shown in the diagram. The same might hold of octants of the spherical germ. Here the initial æolotropy of the whole egg determines that of its segments; that must therefore become four or eight molecular mechanisms, each with precisely the same type of potentiality as that of the whole egg. (See concluding note.)

There may, according to the foregoing view, be such a thing as perfect isotropy in every radius lying in a plane cutting the line from a to b at right angles. This would not, however, be the perfect isotropy of our definition that we are compelled to accept in the form in which it comes to us from the physicist.

As development proceeds, moreover, we have reason to believe that this æolotropy becomes more and more marked, so that eventually the huge metameric molecules become arranged in definite linear, parallel systems, as in the axis cylinders of nerve cells and in muscular tissue. Here the characteristics of the system become the the same in parallel lines, and in any directions at right angles to an axis parallel to these parallel lines of molecules. That is, in certain rectangular directions there is an approximation toward homogeneity. But the completest homogeneity is found to occur in only one direction in parallel lines extending through the mass. This condition we may designate as monotropy. Starting with the extreme æolotropic condition of the germ, we must, therefore, assume that as organization becomes more and more complete, in the progress of development, in the specialized systems of tissues and organs, the molecules become more and more definitely monotropic. Therefore they at last become incapable, as dynamical systems, of exhibiting a complex development such as is manifested by a germ, but capable only of manifesting the special physiological functions entailed by their dynamically and mechanically evolved monotropism.

We can now understand why it is that the germinal matter of a species always remains in an æolotropic state. Since germinal matter is always relieved of specialized functions in the body of the parent, it must perforce remain in its primitive condition of germinal potentiality as a molecular mechanism. Since the germ is material that has been produced in excess of the needs of metabolism of the parent body, as supposed by Haeckel and Spencer, it can do no work for that body. The unbroken continuity of the processes of metabolism has provided the conditions for the continuous or interrupted production of germinal matter.

The nearest approach to a condition of continuity of germinal matter is found in the tissue of the 'growing points' of plants,

where, as in the banana, it has maintained its unabated vigor for probably not less than two thousand years without the help of sexual reproduction. In many organisms the germinal elements must grow and become mature. While in the immature state they do not, for the moment, have the latent potentiality of germs that can, then and there, develop, but may even be destroyed phagocytically, or absorbed by other non-germinal tissues. In still other cases there is no proof that the germinal matter is differentiated, as a complete mechanism, from the first stages of ontogeny onwards, so that the theory of its continuity is not only not always true but is also of small importance. At any rate, it is of far less importance than the fact of continuous metabolism and the gradual advent of monotropism, from a state of germinal æolotropism, effected by the dynamical process of tissue metamorphosis and specialization.

This development of monotropism cannot take place except through the sorting and grouping of specialized molecules, under the domination of forces, the operation of which remains to be discovered in the laws of physiological chemistry and molecular mechanics, and not by an appeal to an unworkable hypothesis that merely covers up our ignorance and impedes our progress by invoking the help of 'gemmules' or 'biophors' that grow and divide like cells. There is no evidence that will enable us to conceive the growth of the molecules of living matter in this way, since we are now dealing with very complex metameric molecular bodies, the growth and disintegration of which is probably essentially similar to the growth and solution of crystals, during the process of metabolism, with this difference that growth and disintegration go on at the same time in living bodies. We do not even know the real nature of the chemical changes that go on in these molecules and determine their structure. That the forces that do determine this are of a chemical nature, operating under very peculiar conditions, we may be certain. The complexity of these bodies, and their complex relations to one another, give us all the mechanism we need in order to account for the phenomena of heredity.

One-half or one-quarter, or an uneven part of the oösperm (Loeb), will operate in the same way as the whole. If we accept the dynamical hypothesis here proposed we are relieved of going to the length of the absurdity of assuming that by dividing a germ we multiply its 'biophors' as many times by two as we have made divisions, or of postulating 'double' or 'quadruple determinants.' The arithmetical impossibility of multiplying by a process of division is, as we see in this case, too much for any non-dynamical corpuscular hypothesis. Where the division of the germ is unequal, as in some of Loeb's experiments, we should, on the basis of a preformation hypothesis, be compelled to suppose that the 'double determinants' were unequally divided.

Regeneration is also to be explained upon the basis of a dynamical theory, as well as polymorphism, alternation of generations, reversion, and so on. We find indeed that it is only the same kind of tissue that will regenerate the same sort after development has advanced a considerable way. Monotropism has been attained by each kind of tissue, and this prevents the production of anything else but the one sort, in each case, after tissue differentiation has proceeded a little way. Polymorphic or metagenetic forms are to be accounted for in the same way as constantly repeated ones. Like the latter they are produced by the operation of a molecular mechanism, the story of the transformation of which is not told off in a single generation, but in the course of several distinct ones. Sex itself is thus determined and must in some way depend upon subtle disturbances of the transforma-

tion of the molecular mechanism of the germ, the nature of which is still quite unknown to us.

Equally remarkable are the phenomena of heteromorphosis described by Loeb, whose experiments prove that some animals, like most vegetable organisms, may adjust the molecular machinery of their organization in any new direction whatever that may be arbitrarily chosen, so as to realize the continuance by growth of the same morphological result as that which characterized them normally. These experiments would at first thought seem to prove that some organisms were isotropic, but such a conclusion is exceedingly doubtful. It may be that such organisms are, as molecular mechanisms, when subjected to new geotropic and heliotropic conditions, capable of correspondingly new adjustments of their molecular mechanical structure. But this would not be proof of isotropy—only proof of the assumption of a new condition of æolotropy, adjusted in respect to a new axis of reference, that also coincides with some part of the earth's radius prolonged into space. This readjustment of the molecular mechanism may be effected in some way by gravity, as Loeb himself has suspected. It is certainly not due to the control of any lurking 'biophors,' since it is a purely mechanical readjustment of an ultra-microscopic structure to new conditions which cannot be effected in any other than a mechanical way.

The production of monstrosities also may be explained by a dynamical hypothesis, provided we assume that the forces of ontogeny must operate against the statical equilibrium of the parts of the germ at every step. Especially if we assume in addition, as is born out by facts, that the æolotropy and consequent recapitulative power of the germinal substance is most marked in certain regions of the embryo. These regions, if their molecular equilibrium be mechanically or otherwise disturbed by division during development, will assert their germinal potentiality and produce an embryo, the relations of which to that already formed alongside of it will be modified by the statical conditions of surface-tension afforded by the adjacent embryo or the underlying yoke, or by both combined. This is beautifully illustrated by a host of facts. Double toes must have so arisen, as is proved by the direct experiments of Barfurth, some of which I have repeated, as well as by what happens when the toes of an Axolotl are persistently nibbled off by another animal, when duplication may not only take place in the horizontal plane of the foot or hand, but also in the vertical one. In this way a number of supernumerary toes may be caused to arise from a single stump, provided the re-growth of the toe be so interfered with as to compel regeneration from two terminal regenerative surfaces instead of one. This must follow from the law demonstrated by Barfurth's experiments, namely, that the regeneration of an organ tends to occur uniformly over and in a direction normal to the regenerating surface. In this way it is possible to mechanically determine the direction in which a regenerated part shall be reproduced by merely making changes in the angular relations of the plane of the regenerating surface to that of the axis of the body, as indicated by the diagram in Fig. 2 of the regenerated tail of a tadpole. Here

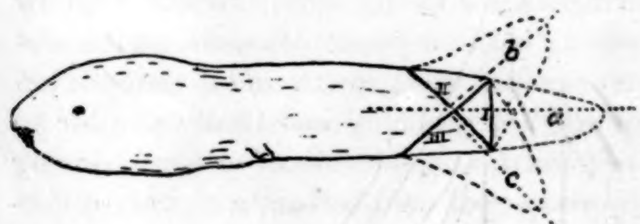

Fig. 2.

the line I indicates the plane along which the tail has been removed, upon which regeneration will restore the tail straight

backward to the dotted area *a*. If the plane of section is along the line II the tail will regenerate upward so as to be restored over the area indicated by the dotted line enclosing *b*. If the plane of section of the tail be along III the tail will be regenerated downward to the dotted line enclosing the area *c*. It is therefore evident that Barfurth's law determines the inclination of the axis of the regenerated part to the body-axis, through the different conditions of surface tension that must be set up over regenerating surfaces, whenever the inclination of these to the axis of the whole organism is changed.

New equilibria of surface tension established reciprocally between the cohering but independently developing segments of the oösperm of the sea-urchin, that have been imperfectly separated by mechanical or other means, also cause changes to be produced in the forms of the single larvæ of such coherent groups, and in the spicular skeleton, for the same reason, as is proved by Figs. 23 to 25 given by Professor Loeb.* Those figures also illustrate the thesis that the æolotropy of the distinctly developing segments of the egg must be nearly the same, and that component or resultant equipotential surfaces are developed by the interacting molecular machinery of such coherently developing or compound larvæ.

The angular divergence of duplicated tails and toes as well as the axes of monstrous embryos is explained by Barfurth's discovery, taken together with the principle that division of a germ does not change the æolotropy of its segments. If this interpretation is the correct one, the origin of supernumerary digits must be traced back to mechanical disturbances of the processes of ontogeny. The rationale of the manner in which divergent supernumerary toes may be produced is shown in Fig. 3, representing the regenerating toes of the foot of a salamander.

Biological Lectures (No. III.). Delivered at Woods Holl, Mass., in 1893. Ginn & Co., Boston.

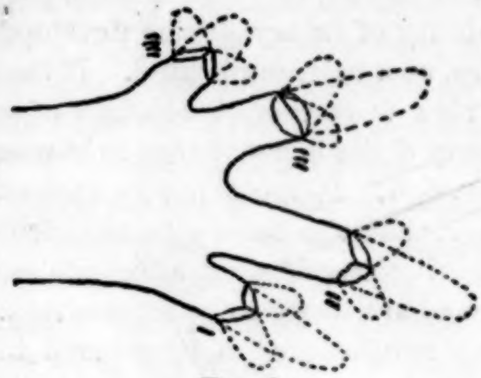

FIG. 3.

If the toes were cut straight across at the points I., II., III., IV., the toes would regenerate normally. If, however, the regenerating surfaces were divided into two areas in each case by a line along which regeneration were prevented, two toes would arise from each surface. The angular divergence of the pairs of supernumerary toes thus produced would be measured by the angular inclination to one another of the two areas at the end of each original toe that was thus doubly regenerated. In other words, supernumerary digits are the results directly or indirectly of something akin to mutilations. That such duplications may be produced by mutilations there can be no doubt, and of their transmission by inheritance to offspring there is also no doubt. These facts make it probable at any rate that regeneration of distal parts, and the likelihood with which they reappear in duplicate, is due to causes similar or identical in character with those that lead to the production of double monsters, by shaking, mutilation or other physical interference with the normal development of the oösperm. The question of the inheritance of mutilations is consequently far from being concluded as viewed from this new standpoint. Much evidence might be adduced in support of my contention did space allow. The hereditary transmission of such monstrosities as supernumerary digits

is well known, and it is a singular fact that it is only the outer digits, *i. e.*, minimus and pollex, or hallux, or those most exposed to the liability of injury during development, that are, as a rule, duplicated. If the foregoing view is correct, the origin of supernumerary digits is not always to be ascribed to reversion. It must not be understood, however, that the theory is here defended that mutilations effected after adolescence is reached are likely to be transmitted.

The 'mutilations' here referred to are hardly to be regarded as such, but rather as the results of mechanical interference or disturbance of the statical equilibrium of those parts of the developing germ that are duplicated, as we see, in obedience to the principle discovered by Barfurth.

Another dynamical factor in development is so generally ignored that it must be especially referred to here. I now refer to the statical properties of the germinal substance in modifying development. Some of its effects we have already taken note of above. Karyokinesis has been shown by Hertwig to be dominated by the principle that the plane of division of a cell is always at right angles to its greatest dimension, a fact readily verified. The greatest dimension of the cell in turn is also often, if not usually, determined by the conditions of free and interfacial surface-tension manifested between the members of a cellular aggregate composing a segmenting egg. This appears to have a determining effect upon the plan of the cleavage. How far and in what way the remarkable movements of the centrosomes that occur during cleavage, and that have been most exhaustively studied by Professor E. G. Conklin, regulate segmentation still remains to be determined. There can, however, be but one explanation of such movements, and that must be a mechanical one, but its nature is entirely unknown. Wilson has shown that the conditions of free and interfacial surface-tension in Amphioxus vary in different eggs from some unexplained cause, so that the earlier cleavages of this form also vary to a corresponding and remarkable degree. In other cases surface-tensional forces operate under similar recurring conditions. In the fish-egg I have witnessed the reappearance of the same or similar interplay of statical energies thrice in succession, so as to produce three similar successive sets of formal changes in the egg that are traceable to the action of similar statical agencies. In *A*, Fig. 4, the

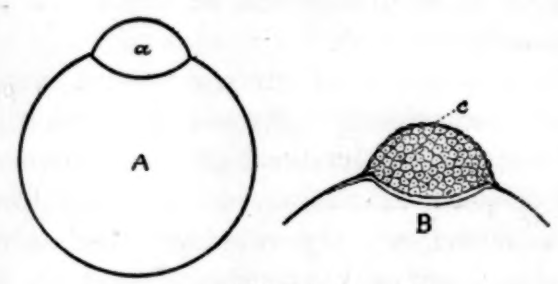

FIG. 4.

germ *a* has assumed a lenticular form of statical equilibrium; after segmentation of the same disk has proceeded some way, as in *B*, the disk, as a cellular aggregate, has again assumed the lenticular form of equilibrium, while the outermost row of cells, *c*, are individually in a similar condition of equilibrium.

These facts are quite sufficient to establish the general truth of the statement that at no stage is the ontogeny of a species exempt from the modifying effect of the surface-tensions of its own plasma acting between the cells as if they were so much viscous dead matter. Such statical effects are not overcome at any stage of the development, or even during the life of any organism. On account of the universal presence and effect of this factor in both the plant and animal worlds, as a modifier of form, we are obliged to consider it as an agent of the first importance in the possible development of the future science of exact dynamical morphology. Its action is so

constant an accompaniment of development that the forces of the latter may be divided into the kinetogenetic, or those that develop movement, and the statogenetic, or those that develop rest or equilibria, amongst the parts of the germ. The kinetogenetic forces are the consequences of metabolism, but the statogenetic forces, though dependent upon metabolism, are produced as a consequence rather of the interaction of the surface layers of the plasma of the cells, contemplated as if they were small cohering masses of viscous dead matter. These masses are separated, in the organism or germ, by interfacial planes, free and interfacial curved surfaces that are the results of segmentation and growth, and the extent of the areas of which obey a law first pointed out in relation to soap-bubbles by the blind physicist Plateau, who showed that such bubbles tended to form interfacial films and surfaces, wherever in contact with each other, of an area that was the minimal consistent with their statical equilibrium.* In this connection it may also be remarked that, inasmuch as the cells of a germ or organism are always in statical equilibrium, their surface layers of molecules also always represent complex systems of equipotential surfaces, no matter how intricate the form of the organism may be. Since the equilibria between the molecules of the surface layers of cells can normally be disturbed only by the metabolism incident to physiological activity, it is evident that the figure of the organism must ultimately be ascribed to the action of metabolism or to the functions of the organism as affecting the physical properties of its plasma.

A statical equilibrium in a living cell may be one in which it is not in contact with others at any point on its surface, as in the case of blood-corpuscles or disks. Or a cell may be greatly extended in one direction, as in the case of the axis-cylinder of a nerve-cell, owing to very unequal surface-tensions developed in one or more directions so as to draw it out into a condition of equilibrium, in assuming which it acquires a great length. Formal changes in cells, no matter how irregular these may become, must be due to alterations of surface-tension due to molecular transformations at certain points on the surface of globular or polyhedral embryonic cells. The final mature form of a cell is a consequence of the assumption of a statical equilibrium amongst its parts, due to the nature of its metabolism and its consequent molecular structure. The statogenetic factors of development are therefore of just as much importance as the kinetogenetic, or those involving motion. The statical forces that are developed in individual cells also act reciprocally between all of the cells of the organism, so that in this way the effect of statogeny extends throughout the entire organism.

If there were no such statical forces to be overridden by the purely kinetic ones developed by the molecular transformations and consequent motions incident to metabolism, provided the latter, together with assimilation, took place, during development, with great rapidity, the ontogeny of an organism would take place with such swiftness that it could not be successfully studied by embryologists. In other words, ontogeny would take place in the twinkling of an eye, and organisms as large as whales might even mature in an instant, provided the coefficients of viscosity and surface-tension of their plasma were to fall nearly to zero, while assimilation and metabolism proceeded with infinite rapidity.

It follows also from what has preceded that we can now form some idea why apparent rejuvenescence occurs in every on-

* Some interesting applications of the geometrical theory of radical axes and centers also apply here that have never been studied in connection with the phenomena of segmentation.

togeny. Every germ must, for assignable reasons, begin its existence in the original, highly complex, æolotropic condition of the plasma of its species. It must therefore begin its career somewhat in the guise of the mechanically unspecialized plasma of a remote unicellular ancestor. Unlike that ancestor, however, the cells that result from its growth and segmentation cohere until a multicellular aggregate results, the different regions of which fall into certain statical states in relation to one another and to the earth's centre, in virtue of the action of the forces of cohesion, friction, gravitation, etc. The different regions of such an aggregate now adjust themselves to the surroundings in such a way that nearly constant effects of light, heat, etc., begin to control or affect the functions of such an aggregate dynamically through its metabolism. Function, thus conditioned, asserts itself under the stress of mechanical adaptation or adjustment that becomes increasingly complex with every advance in ontogeny. Every step in ontogeny becomes mechanically adaptive and determinative of the next. It is thus only that we can understand the wonderful molecular sorting process that goes on in ontogeny, for which others have invoked infinite multitudes of needless 'gemmules,' 'biophors' and 'determinants.'

It is the whole organism that develops in continuity or coördination; not its nuclei, centrosomes, and asters only. The whole organism, molecularly considered, is as fixed and immutable, within variable limits, as a crystal. Its development, moreover, becomes intelligible only if we contemplate its ontogeny somewhat as we would the growth of a crystal, with the additional supposition that its growth is not conditioned by forces operating along straight lines having a constant angular divergence as in the latter. On the contrary, living matter is capable of developing curved bounding surfaces in consequence of the permanently mobile nature and cohesion of its molecules, that, as a complex dynamical mechanism, can operate so as to tell off the tale of its transformation in but one way, in consequence of the order and way in which the energy of its constituent molecules is set free during ontogeny. Upon the completion of ontogeny a phrase is reached in which the income and outgo of metabolism is in equilibrium. The duration of life depends upon the length of time that this equilibrium can be maintained without fatal impairment of the harmonious operation of its mechanism under the stress of the dynamical conditions of life. This may be considered the cause of death, so that the length of the life of the individual is determined by the possible number of harmonious molecular transformations of which its plasma is capable as a mechanism.

The doctrine that cells undergo differentiation in relation to other adjacent cells, or that the destiny of a cell is a function of its position (Driesch), is no doubt true. Nevertheless, we have in organisms machines of such complexity, dynamical potentiality, and power of transformation, that in comparison a study of the theories of crystallography is simplicity itself. In organisms we have the polarities of head and tail, stem and root, right, left, dorsal and ventral aspects, as definitely marked out as are the relations of the axes of crystals. In the organism we have diffuse, intussusceptional growth in three dimensions, by means of the osmotic interpolation of new molecules, whereas, in the crystal, growth is superficial, but consequently also tri-dimensional. In the organism the molecules are mobile within limits; in the crystal they are fixed. Nevertheless, we may justly regard organisms as developing after the manner of crystals, but with the power of very gradually varying their forms by means of variation in the structure, forms and powers of their constituent molecules, in the

course of many generations of individuals.

This variation may be directed by the concurrence of a series of natural conditions operating dynamically (natural selection). Or, interbreeding and crossing, with care or under Nature, may unite by means of reciprocal integration (fertilization) two molecular mechanisms whose total structure and sum when thus united, as in sexual reproduction, may vary by the mere combination of the two dynamical systems (egg and sperm), differing slightly from one another in potentiality. Finally, adaptive changes may be called forth dynamically in the internal structure of such developing reciprocally integrated systems that must be traced back to changes in the mechanism of metabolism of the parent as well as in the germs it gives off. Such changes produced in the germ must become visible in the effects they produce, as transmitted formal changes exhibited in the course of development.

The tendency or trend of development, however, of a given form must be pretty constant, and controlled within comparatively narrow limits by the initial adult or attained structure. That is, what has been attained must formally affect that which is to be attained in future. This is the idea that underlies the *Vervollkommnungs-Princip*, principle of perfecting, of Nägeli. This view also tacitly recognizes the theory of change of function proposed by Dohrn, as well as the theories of substitution, superposition and epimorphosis of Kleinenberg, Spencer and Haacke. Once a condition of stable equilibrium has been reached in the series of transformation of the molecular mechanism represented by the germ, during the development of an organism, we may have what Eimer has called *Genepistasis*, resulting in the fixity or stability of an organic species, under stable conditions.

The cell is a complete organism, but it loses its physiological and morphological autonomy when combined with other cells. We may regard the nucleus, cytoplasm and centrosome as reciprocally related parts; one of them not much more important than the others. The observed behavior of the centrosome would indicate, as Verworn has held, that it is the important agent in cellular metabolism. If this is true, metabolism has certain centers in the cell to and from which molecular transformations are effected rythmically in every direction, with the centrosome as focal points. This view agrees perfectly with the facts, since the rays of the asters may be regarded as the morphological expression of a dynamical process of intermolecular diffusion due to metabolism, as Kölliker has suspected (*Gewebelehre*, 6th ed.).

Such a process would not only serve to alter the surface and interfacial-tensions of the cells during ontogeny, but also vary the osmotic pressure within them. Consequently, we may conceive that all of the phenomena of development, including the appearance and disappearance of cavities within a germ by changing conditions of osmosis, may receive a dynamical explanation. The centrosomes may, moreover, be conceived to lie at the foci of very complex material figures, the boundaries of which are finite equipotential cellular surfaces. These focal points are clearly near or within the nuclei. The equipotential surfaces developed by the sorting or readjusting process that goes on during segmentation in order continually and rythmically to restore the dynamical equilibrium of the molecular germinal aggregate as a mechanically constructed system during life and development, through growth and metabolism, must maintain the shapes of organisms as we see them. The epigenetic theory of inheritance therefore promises us a secure basis upon which to found a theory of the mechanics of development, as well as a theory of the origin of morphological types.

The theory of life may indeed be regarded as having its foundations in cellular, inter- and intra-cellular mechanics and dynamics as conditioned by ontogentic metabolism. The fact that centrosome, nucleus and cytoplasm are represented almost coextensively with the presence of life itself is proof that the fundamental machinery of organization must be the same in the principles of its action, no matter how widely its forms may differ from one another.

The theory that the surface layer of molecules of organisms, whether interior or exterior, are in equilibrium also carries with it the idea that the configuration of all organs and organisms are merely the material expression of gradually built up equipotential surfaces. This gives us a far more rational foundation for a theory of general morphology than the hypothesis of gemmaria proposed by Haacke. During growth and metamorphosis these equipotential surfaces undergo formal changes in size and shape, due to the internal processes of molecular transformation or metabolism. But such changes are continuous, and one stage or form passes into the next palpable one through an infinite number of slightly different forms. Examples of such surfaces may be seen in any organism, vegetable or animal, and at any stage of the same. The principle is therefore of universal application.

SUMMARY.—Preformation of any organism in the germ has no foundation in fact.

All that it is possible to account for upon the basis of a theory of preformation may be much more logically and scientifically accounted for upon the ground of dynamical theory. Such a theory must deny the existence of separate corpuscles or gemmules of any sort in the germ, whose business it is to control development. All that is required is the assumption of a determinate ultra-microscopic molecular mechanism, the initial structure of which determines all of its subsequent transformations. The present theory also denies that there is or can be anything passive in the germ that enters into its composition.

A dynamical hypothesis of inheritance is correlated with all the facts of physiology. It is in harmony with the dynamical theory of sex, that sees only in sexuality the means developed by another dynamical process (natural selection) that increases the powers of a compound germ to survive and vary. It is consistent with the facts of morphological super-position, with the dynamical theory of the limit of growth, and duration of life of organic species. It is also consistent with the view that the initial or potential states of the germs of species are those that must result whenever they are relieved from physiological service to the parent organism. The apparent continuity of germ-plasm is, in many cases, only an effect of the equilibration of the forces of the organism, and has no further significance. It must also deny any assumed isotropy of the germ as inconsistent with fact. It assumes that the æolotropy of the molecular structure of the germ is followed by a gradually increasing simplification of molecular structure of organs as these are built up. Metabolism is assumed to be the sole agent in effecting the mechanical and dynamical rearrangement or sorting of the molecules into organs during development. Specially endowed corpuscles or 'biophors' are not only needless as conditioning form or function, but also out of the question, dynamically considered. No creature can be supposed to have its life or germinal properties associated only with certain corpuscles within it, since we cannot suppose an organized whole dominated by a portion of it; it is not possible, for example, to conceive of individual life except from the entire organism that manifests it. There can be no 'biophors'—bearers of life; the whole organism must do that as an indivisible unit. Corpuscular doctrines of inheritance are

merely a survival in philosophical hypothesis of a pre-Aristotelian *deus ex machina.* The dynamical hypothesis rejects the *deus ex machina*, but finds a real mechanism in the germ that is an automaton, but that is such only in virtue of its structure and the potential energy stored up within it. Every step in the transformation of such a mechanism is mechanically conditioned within limits by what has preceded it, and which in turn so conditions within limits what is to follow, and so on forever through a succession of descendants. The theory of equipotential surfaces, as here applied to organisms, leads to a theory of general morphology that holds of all living forms, and that is at the same time consistent with the facts of development.

EXPLANATORY NOTE TO PARAGRAPH ON PAGE 618.

It now appears that the statement that the quarters or eighths of an oösperm are to be regarded as 'molecular mechanisms of precisely the same type of potentiality' as the whole egg, must be taken with considerable qualification. Loeb (Ueber die Grenzen der Theilbarkeit der Eisubstanz, *Archiv für Ges. Physiologie*, vol. LIX., 1894) has shown that the eggs of echinoderms, if artificially divided, by means of a method of his devising, into quarters or eighths, lose the power of developing beyond the blastula stage. This would appear to indicate that if the egg is subdivided so as to have its parts fall below a certain size, these parts no longer have locked up within them, as molecular mechanisms, as Loeb points out, enough potential energy to transform themselves into completely equipped larvæ. Or, perhaps, the initial æolotropy of the egg does not permit of its subdivision into quarters and eighths without impairing their structure and powers of development.

My own recent experiments have shown that it is possible to incubate for some time the germ of the bird's egg outside of the egg-shell in a covered glass-dish. These experiments also show that restraints to growth developed by the dying of a film of albumen over the germ causes it to be most extraordinarily folded, with many abnormal tumor-like growths from both entoderm and ectoderm, that differ, however, in histological character from the cells of both these layers. These experiments also prove that it is possible to mechanically divide the germ of the warm-blooded Avian type into halves or quarters, and to have these continue to develop for a time.

The converse of the process of mechanical division of the germ we have in Born's remarkable experiments in cutting recently-hatched Amphibian embryos in two, and placing the separated halves again in contact under such conditions as to cause them to grow together, or even to thus graft the half of a larva of one species upon that of another. That such grafting is possible, I can testify, as a result of a repetition of some of the experiments. See Born's paper in *Schlessischen Gesellsch. f. väterländische Cultur: Medicinische Section*, 1894. pp. 13. Supplementing Born's results are Roux's experiments on *cytotropism*, or the reciprocal attraction of isolated blastomeres of Amphibian eggs (*Archiv f. Entwickelungsmechanik*, I., 1894), if brought close together, though at first not in actual contact. There is also some evidence of asexual *caryotropism* as witnessed in the conjugating nuclei of the cells of the intestinal epithelium of land-Isopods (Ryder and Pennington, *Anat. Anzeiger*, 1894).

The experiments of O. Schultze (*Anat. Anzeiger*, Ergänzungsheft zum Bd. IX., pp. 117–132, 1894), by very slowly rotating in a mechanically fixed position the segmenting eggs of Amphibians on a specially constructed clinostat, with the result of disorganizing and killing them, show that such eggs are not isotropic. His production of double monsters in such ova by disturbing, for a time, their geotropic relations, is also significant, while his conversion of the meroblastic amphibian egg into a holoblastic, evenly segmenting one by merely rotating it through 180° out of its normal geotropic relation, and allowing it to complete its segmentation in an inverted position, proves that the egg can be made structurally homogenous by mere mechanical means, but at the expense of its power to complete its development. This is further proof that the egg is not isotropic in the sense in which that word is used by natural philosophers.

Since the appearance of the short but important paper by Prof. E. B. Wilson and A. P. Mathews (*Jour. of Morphology*, Vol. X., No. 1, 1895), in which they deny the existence of the centrosome, it becomes necessary for me to explain that the word 'centrosome' is used in the text in the sense in which they use the expression 'attraction spheres.' Their discovery that the ovocenter, or attraction sphere of the egg, disappears after the expulsion of the two polar cells in echinoderm eggs, to be replaced by the sperm-center, is of the greatest significance, and may explain the reason why parthenogenetic eggs develop, namely, as a consequence of their retention of an ovocenter. The new facts that these two able workers have disclosed are entirely in harmony with a dynamical theory of fertilization and sex.

JOHN A. RYDER.

SCIENCE IN CANADA.

The awakening from long indifference as to the constant wasting, from various causes, of the timber resources of this continent, which some dozen years ago gave rise to a series of forestry congresses, has produced a considerable mass of literature, mainly economic, but to some extent also scientific, in Canada as well as in the United States. Not only the Dominion, but the provincial authorities as well, took action on the matter for the purpose of at once arresting wanton destruction of still existing forests, of re-afforesting denuded areas and of planting trees in the scantily timbered region between the Great Lakes and the Rocky Mountains. Something has also been done in the introduction of varieties, for sanitary and ornamental uses, from the like climates of the Old World. The scientific societies have done their share in keeping alive the interest created by this far-reaching movement. The latest of the monthly meetings of the Natural History Society of Montreal was devoted to this subject, the Hon. J. K. Ward having read a comprehensive paper on 'Canada's timber resources and lumber industry.' Mr. Ward's paper was largely historical and economic. He gave an interesting sketch of the lumber business from the year 1667, when the first timber ship was despatched from Canada to Europe; spoke of the relations between lumbering and colonization and touched on the great wealth of precious timber growing in Canada west of the Rockies. The lecture was scientific indirectly only and in its suggestions.

In view of the agitation for the admission of the island of Newfoundland into the Dominion, it may be of interest to recall that Mr. B. L. Robinson and Mr. Hermann Schrenk, of Harvard University, made a botanical exploration last July and August through the Exploits Valley and other parts of that island. They obtained more than 7,000 specimens of flowering plants and vascular cryptogams, as well as (incidentally) a number of thallophytes. What is especially noteworthy, as parallel phenomena are well known in Canada, is that though the Exploits Valley is more than 200 miles north of St. John's it 'showed a richer and more advanced vegetation, indicative of a deeper soil and milder climate.' The report was published in the *Harvard Graduates' Magazine.*

A society that is destined to give a fruitful impetus to botanical research in the Dominion is the Botanical Club of Canada, which originated in a recommendation of the Fourth Section (Biology and Geology) of the Royal Society of Canada, at the annual meeting held in Montreal, in May, 1891. It is, however, entirely independent of that Society, with which it holds only the relations common to the other associated scientific societies of the Dominion. "The objects of the Club are to adopt means, by concerted local efforts and otherwise, to promote the exploration of the flora of every portion of British America, to publish complete lists of the same in local papers as the work goes on, and to have these lists collected and carefully examined in order to arrive at a correct knowledge of the precise character of our flora and its geographical distribution." This Club comprises Newfoundland (as does the Royal Society of Canada), not only in the scope of its operations, but by official representation. Prof. George Lawson, Ph. D., LL. D., of Halifax, N. S., is president; Dr. A. H. MacKay, B. Sc., Halifax, is general secretary-treasurer. Prof. D. P. Penhallow, B. Sc., McGill University, is secretary for the province of Quebec; Dr. J. A. Merton Wingham, for Ontario; Dr. A. H. MacKay, for Nova Scotia; Mr. G. U. Hay, M. A., Ph. D., St. John, for New Brunswick; Mr. Francis Bain, North River, for Prince Edward Island; Rev. A. C. Waghorne, St. John's,

for Newfoundland; Rev. W. A. Burman, B. D., Winnipeg, for Manitoba; Mr. T. N. Willing, Calgary, for Alberta; Rev. C. W. Bryden, Battleford, for Saskatchewan; Mr. A. J. Pineo, B. A., High School, Victoria, for British Columbia. The foregoing officers were elected on the 25th of May, 1894.

An interesting report of the work of the year 1893–94 was presented at last year's May meeting of the Royal Society at Ottawa, and is published in the *Proceedings*. What is most striking in it is the evidence which it affords that the creation of the Society has proved an incentive to increased industry in field work in distant and out-of-the-way places—in Newfoundland (special attention being called to Mr. Waghorne's work), in the Territories, in British Columbia and on Prince Edward Island. In British Columbia 100 members had been enrolled through Mr. Pineo's efforts, and 1,400 species (of which 30 were new) collected under the direction of Prof. Macoun. In Nova Scotia the work was largely associated with phenological observations. Besides excellent local work, the operations in Ontario included a series of papers by Mr. James Macoun on the plants in the Herbarium of the Geological and Natural History Survey at Ottawa, which appeared in the *Canadian Record of Science*. In Quebec the most important work done was that of Prof. Penhallow, in the determination of the species of American Coniferæ by the structure of the stem, a research of recognized importance in the development of phanerogamic botany. In all the provinces the creation of the Club has already had a marked educational effect, the more intelligent teachers in many localities having engaged with energy in the work. Before the formation of the Club the only Canadian institution whose operations covered the Dominion was the Survey just mentioned, to the botanical work of which Mr. Robinson makes laudatory mention in his Exploits Valley report. In all the older provinces, however, there have long been scientific societies of whose objects botanical exploration formed a leading feature.

The gift by Mr. W. C. McDonald, of Montreal, of thirty-five acres of convenient and suitable land for the formation of a Botanic Garden in connection with McGill University, must very materially aid in the promotion of botanical research in Montreal and will prove a prized boon to Prof. Penhallow and his students. This gift, the deeds for which were formally signed on the 3d inst., is only one of many substantial proofs that Mr. McDonald has given of his interest in scientific education. At the convocation of the University on the 30th ult. the vice-principal was able to announce that, during the session just closing, the students had for the first time surpassed the thousand. That this augmentation is largely due to the increased attendance of the Scientific Faculties (medicine, comparative medicine and applied science) is an open secret. Ten years ago the attendance did not reach five hundred. As the vice-principal (Dr. Alexander Johnson) pointed out, increase of numbers, though desirable, is not the *summum bonum*. He hoped the time would come when all graduates would be first of all graduates in arts. Prof. Callendar, without decrying Latin or Greek, deprecated the neglect by scientific students of their mother tongue, which every student of science should be able to write correctly and clearly.

Professor Bovey, D. C. L., M. Inst. C. E., Dean of the Faculty of Applied Science, after saying that the students enrolled in his Faculty this year numbered 187, an increase of 15 per cent. over the previous year, mentioned among recent improvements a course in Kinematics (Professor Nicholson); the addition of practical mining and underground surveying to the course in Mining Engineering (Professor

Carlyle); the establishment of graduates' courses and arrangements made to facilitate the prosecution of research work, so as to take advantage of the splendid equipment for that end now possessed by the University. This consists of laboratories of mathematics and dynamics, fully provided with instruments of measurement, gravity balances, machines for experimenting on the laws of motion, etc.; three chemical laboratories for qualitative and quantitative work and for original investigation, and supplied with Becker & Son (4) and Bunge (1) balances; a Trœmner bullion-balance; a Laurent polariscope, Dubosq spectroscope, etc.; the McDonald physical laboratory of five stories, each 8000 square feet area, including elementary and special laboratories for heat and electricity; rooms for optical work and photography; two large laboratories arranged for research, with solid piers and the usual standard instruments, etc.; the electric laboratory, with Kelvin electric balances, a Thomson galvanometer, two dynamo-meters (Siemens), voltmeters, ammeters, etc.; the magnetic laboratory, the dynamo room, the lighting station, the accumulator room, geodetic, hydraulic testing, thermo-dynamic and mechanical laboratories. The McDonald Engineering Building and its equipment were the gift of the same generous friend of scientific education whom McGill University has just thanked for its botanic garden. Mr. McDonald also contributed liberally towards the erection of the workshops built on the endowment of the late Thomas Workman, merchant, of Montreal. These consist of machine shop, foundry, smith shop and carpenter, woodturning and pattern-making departments, and are intended, under the direction of the professor of mechanical engineering, to familiarize the student with the materials and implements of construction.

Although Prof. Milne (whose recent loss every friend of science deplores) and other seismologists are wont to class the earth movements of the United States and Canada under a common head, Canada has had a fair proportion of such disturbances all to herself. Every student of Canada's annals has had his attention drawn to the series of earthquakes which caused such consternation in the year 1663, and its extraordinary moral effects. On the 17th ult. a shock varying from severe to slight or barely perceptible was felt on both sides of the St. Lawrence, though mainly on the south side in what are called the Eastern Townships. Nearly two years ago a somewhat similar shock was felt, and nearly at the same hour, between eleven and noon. This earthquake was distinctly felt in Montreal. The most formidable visitation of the kind in recent times occurred twenty-five years ago. It cleared even the court rooms and filled the streets with frightened groups.

The Royal Society of Canada met at Ottawa on the 15th inst. A programme of considerable scientific interest was gone through.

The death of Mr. Walter H. Smith, well known in Montreal for more than twenty years as an astronomer and publisher of Smith's Planetary Almanac, is sincerely regretted by all who knew him. He was for many years connected with the Montreal *Witness*, in which paper his contributions on astronomical subjects were always read with interest, and were widely reproduced. He died on the 3d inst., in his forty-third year. He was a native of Wiltshire, England, but had lived more than half his life in Canada. J. T. C.

CARL LUDWIG.

WITHIN a few months Germany and the world have lost three great men, Helmholtz, Freytag and Ludwig. Of these three Carl Ludwig, the physiologist, and the intimate friend of the other two, died in Leipsic on April 27th, 1895, at the age of

seventy-eight, after a life rich in scientific achievement.

The world at large can never realize the great debt that the world of science, and through it the world at large, owes to the tireless brain and the skilful hand of this modest Leipsic professor. Ludwig combined, in an almost ideal manner and inseparably, great investigating power and great teaching power. An investigator himself, throughout the course of his busy life he trained between two and three hundred investigators, and more than any other man since Johannes Müller he has directed the course of physiological research. The numberless publications from his laboratory bear the names of his pupils and rarely his own, but the inscription, 'Aus dem physiologischen Institut zu Leipsic,' is the seal of their worth.

Ludwig was a man of the broadest sympathies and culture, restless and eager for knowledge within or without the boundaries of his own science. But he was content to study specific problems and to refrain from baseless and sweeping hypotheses. In the fifty-three years of his constant labor he left untouched few fields of the physiology of his time, and he never delved lightly or superficially. A record like his is rarely equalled. To the end he maintained his interest and activity fresh, and at the age of seventy-five he wrote to an American friend, "Ueberall liegt so viel brach, überall giebt es so viele Lücken, dass man bald mehr Aufgaben als Kräfte besitzt."

It was a memorable day for biology when Ludwig conceived the idea of the kymograph, the instrument used for recording physiological movements, for the invention of the kymograph marked the introduction of the graphic method into physiology. Ludwig once wrote, "Observation and experiment alone bring the light that illuminates the secret ways of nature." The graphic method has made observation and experiment exact, and has revolutionized the biological sciences. Ludwig is responsible for much of the apparatus of precision now in use in physiological laboratories. To him must be ascribed also the fruitful method of separating single organs from the rest of an animal body, and maintaining them for study in a vital condition, a process indispensable to the understanding of function in a complicated organism.

Besides these additions to method, among the more noteworthy of his many contributions to physiology, either alone or in conjunction with his pupils, may be mentioned: numerous facts and principles regarding the dynamics of the circulation of the blood; the details of the heart's action; the location of the vaso-motor centre; the discovery of the depressor nerve; the mutual relations of respiration and circulation; the blood gases; many anatomical and physiological advances regarding the lymphatic system; the secretory function of the chorda tympani nerve; the mutual relations of gland secretion and blood circulation; gas exchange and production of heat in tissues; the presence of inosit, uric acid and other substances in the animal body; numerous facts regarding the metabolism of specific tissues; the course taken by the food-stuffs in absorption; the minute physiological anatomy of the kidney, the liver, the intestine, the pancreas, the salivary glands, the heart, the skin, etc.; many facts regarding general muscle and nerve physiology, the central nervous system and the special senses.

The leading events in Ludwig's life are as follows: Carl Friedrich Wilhelm Ludwig, the son of a Hessian army officer who served in the Napoleonic wars, born in Witzenhausen December 29th, 1816; studied in Erlangen and Marburg; M. D., Marburg, 1839; prosector in anatomy, Marburg, 1841; privat-docent in physiology, Marburg, 1842; extraordinary professor of comparative anatomy, Marburg, 1846; professor of anatomy

and physiology, Zürich, 1849; professor of physiology and zoölogy, Vienna, 1855; professor of physiology, Leipsic, 1865.

Probably few American physiologists received the news of Ludwig's death without a feeling of sadness far beyond that occasioned by the loss to science. Ludwig liked America and Americans, and many of his colleagues upon this side of the Atlantic have been his pupils and have found in him a warm personal friend. His wit, his sympathy, his breadth of mind, his love of books and of music, were conspicuous. To work with him was to receive the undying stimulus of a master mind and to feel the charm of a simple, sweet, winning personality.

FREDERIC S. LEE.

COLUMBIA COLLEGE.

CORRESPONDENCE.

THE FROG WAS NOT BRAINLESS BUT DECEREBRIZED.

IN the report of the meeting of the Association of American Anatomists last December in SCIENCE for March 15, 1895, p. 297, it is said that 'Dr. Wilder exhibited a Brainless Frog, etc.' The animal shown had been deprived of his cerebrum Dec. 7, 1894, for demonstration to my class in physiology of the points first, I believe, observed by Goltz. The brain was transected at the diencephal (thalami) and the entire cerebrum removed as described by me in 1886.* The frog was unusually large and vigorous, and was exhibited partly on that account, and partly because when it dies the condition of the brain will be determined and reported to the Association. At this writing, however, it is still living and has been photographed in various attitudes, amongst others while maintaining its balance on a cylinder *by 'backing' instead of going forward as usual.*

The object of the present note is to reprobate the use of *brainless* and *decerebrized* as interchangeable terms. The latter alone was used by me at the meeting, and was accessible in type-writing to all who were present. Nevertheless, both at that time and afterward, there appeared many newspaper paragraphs as to 'Dr. Wilder's brainless frog.' An attempt to correct the misapprehension through the Associated Press only made the matter worse, for I was promptly credited with 'another brainless frog.'

Perhaps, however, we ought not to condemn the popular confusion of terms too strongly in view of the following example among professional anatomists. At the Tenth International Medical Congress in Berlin, August 5, 1890, Professor Sir William Turner, F. R. S., etc., delivered an address, the official title of which, as printed in the *Journal of Anatomy and Physiology* for October, is 'The Convolutions of the Brain;' the real subject is The Fissures of the Cerebrum.

BURT G. WILDER.

ITHACA, N. Y., May 25, 1895.

* Remarks upon a living frog which was decerebrized more than seven months ago. *Amer. Neurol. Assoc. Trans.*, 1886. *Jour. Nerv. and Mental Dis.*, XIII., p. 30. (Abstracts in *N. Y. Med. Record*, July 31, 1886, SCIENCE, Aug. 7, 1886, and *Medical News*, Aug. 7, 1886.)

TEXT-BOOK OF INVERTEBRATE MORPHOLOGY.

TO THE EDITOR OF SCIENCE: A reply to a book review is undoubtedly in many cases inadvisable, but there are certain statements in the review of my Text-book of Invertebrate Morphology in your issue of May 3d which seem, as a matter of justice, to call for some comment. A reviewer has a perfect right to express his opinion concerning the views set forth by an author, but the latter has a right to expect that his statements will not be misrepresented either directly or by implication, and I wish to call attention to certain misrepresentations

contained in Professor Packard's review.

In the first place the following statement is made: "Thus in writing of the Brachiopoda the author speaks of the bivalved shell 'similar to that of the bivalve mollusk,' but he does not add that the shells are dorsal and ventral, a point in which they differ from any mollusk." Professor Packard must have read my description of the Brachiopoda very perfunctorily; otherwise he would have seen fifteen lines further on the statement: "Since the mantle-lobes are dorsal and ventral in position, so too are the valves of the shell," and a little further on still he would have found an express statement that there are important differences between the shells of the Brachiopods and those of the bivalve mollusks.

Secondly, it is implied in the review that I state that the thoracic segments in the butterflies and Diptera 'seem to be reduced to two, etc.' If my entire statement had been quoted my meaning would have been clear. The concluding words of the sentence, replaced in the review by 'etc.,' reading 'owing to the close association of the metathorax with the first abdominal segment.' The reviewer implies that I state that but two segments occur in the insects mentioned, whereas I distinctly imply that all three are present.

Thirdly, the reviewer implies that I state on p. 414 that the elements of the ovipositors (in insects) are situated on the 'last abdominal segment.' As it happens at p. 414, it is the Isopods, and not the Insecta, which are under consideration. My statement regarding the ovipositors of insects are: (1) "Cerci, ovipositors and copulatory organs are frequently borne by the posterior abdominal segments" (p. 489); (2) "The genital orifice is situated on the ventral surface of the ninth abdominal segment and is usually surrounded by a number of papillæ, or sometimes by long processes which serve as ovipositors, and are to be regarded simply as processes of the segments from which they arise, and not as modified limbs" (p. 497). In both cases I use the word 'segments' and not 'segment,' and in neither case do I state that the ovipositors are on the last segment.

There are several other points which might be similarly commented upon, but I do not desire to occupy space by multiplying examples of inaccuracies in the review. Surely, in the review of a scientific book evidence of ordinary care in the preliminary perusal of it is to be expected.

Yours truly,

J. PLAYFAIR MCMURRICH.

UNIVERSITY OF MICHIGAN, May 7th, 1895.

[IN reply to Professor McMurrich I regret to say that I did overlook the words on p. 269, to which he draws attention, although I still think the dorsal and ventral relations of the valves had better have been emphasized in the beginning of the last paragraph of the preceding page. In regard to the second point, I still think that the expression 'seem to be reduced to two' is unnecessary and a grain misleading. Third, on p. 489 ('p. 414' is a printer's error, for which the reviewer is not responsible) the sentence in question still seems to me to be vague, inexact, and in part incorrect. The cerci *are* the homologues of the other jointed appendages of the body, as may be seen in the cockroach and other orthoptera, as well as Lyda, and the Cinura (Machilis). This and the few other errors noted by us are blemishes which can easily be corrected in a second edition. The charge that 'ordinary care' was not exercised by the reviewer is a gratuitous one. In conclusion, I may say that I regard the book as a most excellent and useful one, and wish it every success, as it fills a vacancy hitherto existing in our literature.

A. S. PACKARD.]

SCIENTIFIC LITERATURE.

The Mechanical Engineer's Pocket Book. By WM. KENT. New York, J. Wiley & Sons, 1895. 168 illustrations, pp. xxxi.; 1087, 16 mo. $5.00.

This 'pocket-book,' although altogether too large for the pocket—as are, in fact, all these books, when meeting the requirements fully—is the most important and valuable accession to the portable library of the engineer that has recently appeared. Its scope is purposely confined to those subjects which are of main interest to the mechanical engineer, including the electrical engineering branch, and matters assignable to civil engineering, distinctively, are omitted; it being assumed that the interested engineer will find them in his 'Trautwine.' The author of the new 'pocket-book' is a distinguished engineer and metallurgist, and has had a peculiarly fruitful and fortunate variety of experience in those departments. He supplemented a mercantile education and some experience with a course of study in mechanical engineering, and subsequently had charge of iron and steel works in Pittsburgh, edited a technical journal, was the responsible laboratory assistant in charge of important work of the 'United States Iron and Steel Board,' and has enjoyed a most unique and helpful experience as a consulting engineer. No one could better comprehend precisely what is demanded of the author of such a book.

Throughout a period of now many years material was in process of accumulation, as advised by Nystrom: 'Every engineer should make his own pocket-book.' The construction of the book in hand was commenced at the request of the publishers, who selected the presumably best prepared man for the work, and the result of four years of labor is an admirable, an extensive and a 'meaty' volume.

The section devoted to the materials of engineering, their strength and their properties, is peculiarly valuable and complete. It is a department in which the author is thoroughly at home and with which he has all his life been familiar. The revision of the old formulæ and their constants has been very carefully and completely performed, and this work in itself constitutes a great boon to the engineer. The wide range of difference of proportions of parts of engines and machines observed among contemporary builders and 'authorities' has been the subject of long and conscientious labors. When it is said that sizes of important parts, in the best practice, for 'low-speed' and 'high-speed' engines, respectively, average as four in the one to seven in the other, and when it is known that variations of ten to one, in certain proportions of parts, among well-known makers, are known to exist, the importance of this revision becomes appreciable.

Experimental data are collated to date, and in immense quantity in all departments, and the theory of construction, as far as required and appropriate to such a book as this, has been well condensed and revised, not only by the author, but by specialists whose aid has been sought by him.

The book is especially rich in matter relating to the steam-engine and steam-boilers, stationary, marine and locomotive, and a moderate amount of space is well utilized by a very condensed resumé of principles and practice in electrical engineering. It may perhaps be fairly anticipated that this section will grow somewhat with the rapidly succeeding editions of the book which, it is safe to predict, will follow. Refrigerating machinery here, for the first time, finds space in some degree commensurate with its growing importance, and theory and practice are judiciously presented with data derived by the best experiments yet reported.

This book has more importance, and de-

serves much more space, than so incomplete a notice would indicate; but it is only practicable here to give the briefest possible indication of its contents, and to advise everyone interested in the subjects treated to examine the work and judge it for himself. Mr. Kent and his publishers —who have put up the book in excellent shape in all respects—are to be heartily congratulated on the outcome of their long struggle with the most difficult task that authorship knows—the condensation of a a great mass of useful special information into manageable and compact form. The product of their efforts is a mechanical engineer's pocket-book covering the field with remarkable completeness, correct as to theory, rich in data, supplying all the tables, 'constants of nature,' and results of scientific research in its department, required by the practitioner, and in marvellously compact form.

In size, type, paper and presswork, binding and finish, the book is fully up to the established standard for such publications. It seems remarkably free from printers' and other errors—although it must undoubtedly fail of absolute perfection in this respect in a first edition—and is a credit to all concerned in its production. It is a great work well done.

R. H. THURSTON.

Birdcraft, a Field Book of Two Hundred Song, Game and Water Birds. By MABEL OSGOOD WRIGHT. Pp. 317. 15 double plates, mostly colored. New York and London, Macmillan & Co. 8°. May, 1895. Price, $3.00.

On opening Mrs. Wright's *Birdcraft*, fresh from the press, one is likely to exclaim 'what horrible pictures!' and wonder how a reputable publisher or author could permit such atrocious daubs to deface a well printed book. But in spite of these staring eyesores, which certainly prejudice one against the work, the text contains much of interest and, taken as a whole, is well written. The spirit of the book is in touch with the popular and growing fashion of studying birds in the field, and its chief purpose seems to be to interest the novice and aid in identifying birds 'in the bush.' It contains introductory chapters on 'the spring song,' 'the building of the nest,' 'water birds,' 'birds of autumn and winter,' and 'how to name the birds.' The book proper begins with a 'synopsis of bird families,' followed by popular descriptions and short biographies of 200 species—mostly well-known eastern birds—and ends with keys for the ready identification of males in spring plumage. The utility of such keys can be tested only by actual use. These are simple and look as if they would be helpful to the beginner, though it almost takes one's breath away to find the robin classed with the cardinal and tanager under 'birds conspicuously red.'

Most of the biographies are based on the author's field experience in southern Connecticut, and as a rule are interesting and accurate. Now and then misleading statements creep in, particularly with reference to the geographic ranges. For instance, the white-eyed vireo, chat, orchard oriole, and other Carolinian birds are said to inhabit the 'eastern United States,' while, as a matter of fact, they are absent from the northern tier of States and New England, except in the southern parts. Other surprising statements may be traced to popular prejudice. Thus the author says of the Blue Jay: "Here is a bird against whom the hand of every lover of song-birds should be turned * * * for the Jay is a cannibal, not a whit less destructive than the crow. * * * Day by day they sally out of their nesting places to market for themselves and for their young, and nothing will do for them but fresh eggs and tender squabs from the nests of the song-birds; to be followed later by berries,

small fruit and grain." The same sweeping ignorance and prejudice characterizes her account of the crow, of which she says: "This is another bird that you may hunt from your woods, shoot (if you can) in the fields and destroy with poisoned grain. Here he has not a single good mark against his name. He is a cannibal, devouring both the eggs and young of insect-destroying song-birds." As a matter of fact, the eggs and young of wild birds and poultry together form less than one per cent. of the food of the crow, as determined by the examination of about a thousand stomachs in the U. S. Department of Agriculture. So with grain; sprouting corn forms only two per cent. of the entire food, most of the corn eaten by crows being waste grain picked up, chiefly in winter, in fields and other places where its consumption is no loss to the farmer. On the other hand, mice and other injurious mammals form $1\frac{1}{2}$ per cent. of the food of crows; and insects no less than $23\frac{1}{2}$ per cent.

The colored plates are execrable. Most of them are cheap, coarse, dauby caricatures, taken second-hand from Audubon, who would turn in his grave if he saw them. In addition to these, there are five uncolored process reproductions of water birds and birds of prey. The latter are from Dr. Fisher's *Hawks and Owls of the United States* (published by the U. S. Department of Agriculture) and, though poor, are by far the best illustrations in the book.

Excepting the plates, the book is neatly gotten up and well printed. A novel and useful feature is the insertion of the common name of the bird in heavy-face type at the top corner of the page, in the place usually occupied by the pagination.

On the whole, Mrs. Wright's '*Birdcraft*' may be recommended as a source of pleasure and assistance to the many lovers of nature who are trying to learn more about our common birds. C. H. M.

Anleitung zur Microchemischen Analyse: Von H. Behrens, Professor an der Polytechnischen Schule in Delft. Mit 92 Figuren im Text. Hamburg, Leopold Voss. 1895. 224 pp.

Professor Behrens first wrote this book in French, and it was published in 1893. An English translation by Professor Judd appeared soon after. That the author published a German edition so soon speaks for the value of the book. Professor Behrens' text-book is the only one, as indeed he is the chief authority, on this new and important subject. The first half of the book describes the reactions of the elements, giving plates of the crystalline precipitates as seen through the microscope. Part Second treats of the systematic analysis of water, rocks, ores, alloys, and compounds of the rare elements. The chapter on the micro-chemical examination of rocks, by study of slides and of powdered rock is very interesting; indeed, for petrographic research the manual is invaluable, but it is also of great value to the metallurgist in the study of ores and alloys, and to the general chemist in the ordinary run of chemical analysis. E. Renouf.

NOTES AND NEWS.

THE AMERICAN ASSOCIATION.

The preliminary announcement of the forty-fourth meeting of the American Association for the Advancement of Science, to be held in Springfield, Mass., August 28 to September 7, 1895, has now been issued. The arrangements promise an interesting and successful meeting.

The first general session will be held on the morning of Thursday the 29th. This will give Friday, Monday, Tuesday and Wednesday as the four days entirely devoted to the reading of papers in the sections. Saturday will be given to excursions in the vicinity of Springfield, and more dis-

tant excursions have been arranged to follow the close of the meeting.

At the first general session the President-elect, Prof. E. W. Morley, will be introduced by the retiring President, Prof. D. G. Brinton. Addresses of welcome will be made by his Honor, Mayor Chas. L. Long, and Hon. Wm. H. Haile, President of the Local Committee.

The addresses of the vice presidents before the sections are as follows:

W. LE CONTE STEVENS, before Section of Physics: *The Problem of Aerial Locomotion.*

F. H. CUSHING, before Section of Anthropology.

JED. HOTCHKISS, before Section of Geology and Geography: *The Geological Survey of Virginia, 1835–1841. Its history and influence in the advancement of Geologic Science.*

B. E. FERNOW, before Section of Economic Science and Statistics: *The Providential Function of Government in relation to natural resources.*

MCMURTIE, before Section of Chemistry.

J. C. ARTHUR, before Section of Botany: *The Development of Vegetable Physiology.*

WILLIAM KENT, before Section of Mechanical Science and Engineering.

In the evening the address of the retiring President, DR. DANIEL G. BRINTON, on *The Aims of Anthropology* will be given, followed by a reception by the Ladies' Reception Committee of Springfield.

The affiliated societies meeting in conjunction with the Association are:

The Geological Society of America; August 27 and 28. PROF. N. S. SHALER, Cambridge, *President;* PROF. H. L. FAIRCHILD, Rochester, *Secretary.*

Society for Promotion of Agricultural Science; August 26. PROF. WILLIAM SAUNDERS, Ottawa, *President;* PROF. WILLIAM FREAR, State College, Pa., *Secretary.*

Association of Economic Entomologists.

Association of State Weather Service. MAJ. H. H. C. DUNWOODY, Washington, *President;* JAMES BERRY, Washington, *Secretary.*

Society for Promoting Engineering Education; September 2, 3, 4. GEO. F. SWAIN, Boston, *President;* PROF. J. B. JOHNSON, St. Louis, *Secretary.*

American Chemical Society; August 27 and 28. EDGAR F. SMITH, Philadelphia, *President;* PROF. ALBERT C. HALE, Brooklyn, *Secretary.*

American Forestry Association; September 3. HON. J. STERLING MORTON, Washington, *President;* F. H. NEWELL, Washington, *Secretary.*

The Botanical and Entomological Clubs of the Association will meet as usual during the Association week.

For information relating to membership and papers PROF. F. W. PUTNAM, *Permanent Secretary,* Salem, Mass., should be addressed. For all matters relating to local arrangements, hotels, railway rates and certificates, MR. W. A. WEBSTER, *Local Secretary, A. A. A. S.,* Springfield, Mass., should be addressed.

THE BRITISH ASSOCIATION.

THE arrangements are now completed for the meeting of the British Association, to be held at Ipswich from September 11 to 19, under the presidency of Sir Douglas Galton. The following is the list of sectional presidents nominated by the Council: Section A (Mathematical and Physical Science), Professor W. M. Hicks, of Firth College, Sheffield; B (Chemistry), Professor R. Meldola, of the City and Guilds Technical College; C (Geology), Mr. W. Whitaker, of the Geological Survey; D (Zoölogy, including Animal Physiology), Professor W. A. Herdman, of Liverpool University College; E (Geography), Mr. H. J. Mackinder, Reader at Oxford; F (Economic Science and Statistics), Mr. L. L. Price, Bursar of Oriel College, Oxford; G (Mechanical Science), Professor L. F. Vernon Harcourt, of University College, London; H (Anthro-

pology), Professor W. M. Flinders Petrie, of University College, London; K (Botany), Mr. W. T. Thiselton-Dyer, Director of the Royal Botanic Gardens, Kew. The new President will deliver his inaugural address on September 11th. The two evening discourses will be given by Professor Silvanus Thompson, on 'Magnetism in Rotation,' and by Professor Percy F. Frankland, on 'The Work of Pasteur and its Various Developments.' There will be, as usual, two soirées, and also excursions to places of interest in the neighborhood of Ipswich.

MECHANICAL INTERPRETATION OF VARIATIONS OF LATITUDE.

UNDER this title, in No. 345 of the Astronomical Journal, Professor R. S. Woodward seeks to deduce the law of variations of latitudes from dynamical considerations. Starting with the hypothesis that the earth is a body of variable form, the general differential equations of rotation of such bodies are derived by means of the Lagrangian method. These equations are then shown to admit of considerable simplification when applied to the earth by reason of the fortunate circumstances that the variations of latitudes are very small, and that the principal moments of inertia of the earth vary exceedingly slowly. The integrals of the resulting equations give the rectangular coordinates of the instantaneous pole of the earth with respect to its pole of figure. The characteristic motion of the instantaneous pole is found to be the resultant of three distinct parts, namely, motion in a circle about the pole of figure with two series of elliptical motions superposed. This characteristic motion is subject, nevertheless, to some fluctuations arising from volcanic and similar impulsive disturbances, as well as from irregularities in meteorological processes.

The general features of latitude variations thus deduced from a purely theoretical basis agree with those arrived at inductively by Dr. Chandler in his elaborate researches. Only one difficulty, in fact, seems to stand now in the way of a satisfactory accordance of theory and observation, and that is the prolongation of the period of the Eulerian cycle from 305 to 428 days. A considerable amount of space is devoted by the author to a discussion of this difficulty. He attacks the validity of the method of deriving the period of that cycle from the ratio furnished by precession, and concludes that the period so derived 'can no longer be maintained as a dogma of dynamical astronomy.' Of several causes which may modify this period, he considers the principal one to be the tide entailed by the motion of the instantaneous axis of rotation about the axis of figure. The order of magnitude of such a cause essential to account for the discrepancy is shown to be very small. The main object of the paper, however, is to obtain a correct specification of the analytical form of the variations in question, leaving to observation and subsequent investigation the determination and reconciliation of the constants which enter that form.

THE MISSOURI BOTANICAL GARDEN.

THE Sixth Annual Report of the Missouri Botanical Garden,* issued on May 3rd, is an octavo volume of 134 pages, with 6 half-tone views taken in the Garden, and 56 plates illustrating plants described in the report.

The report of officers of the Board of Trustees shows that the receipts for the year 1894 were $95,555.97, and the disbursements $75,800.69, of which $35,483.39 was spent on the maintenance and improvement of the Garden and the performance and publication of scientific work; $3,692.29 was for banquets, exhibition premiums, a

* *Missouri Botanical Garden.* Sixth Annual Report. St. Louis, Mo., Published by the Board of Trustees. 1895.

sermon on flowers, and other designated annual bequests of the founder of the Garden, the late Henry Shaw; $21,334.85 went for taxes, and the remainder for office and other expenses incident to the administration of the trust. The report shows an invested or cash reserve of $35,405.03.

From the report of the Director it appears that the herbarium was increased by the addition of 9,307 sheets of specimens, making a total of 231,527 sheets; and 752 books and 1,165 pamphlets were added to the library, making a total of 7,631 books and 9,822 pamphlets. Attention is called to the establishment of a 'Henry Shaw medal for the introduction of a valuable plant,' open to competition in any line of decorative horticulture at the annual flower show held in St. Louis, and to the provision now made for receiving additional pupils in gardening at the nominal charge of $25 per year for tuition.

The scientific papers, which constitute the bulk of the volume, consist of a revision of North American species of Sagittaria and Lophotocarpus, by Jared G. Smith, with habit and detail illustrations of all of the species; a study of Leitneria Floridana, by William Trelease, illustrated by 15 plates showing the structure of this curious tree, the wood of which has a specific gravity of only 0.207, which is much lower than that of any other described wood, or even cork (0.240); studies of the dissemination and leaf reflexion of Yucca aloifolia, made in Florida, by Herbert J. Webber, and illustrated by three plates; notes and observations on new or little known species, by Jared G. Smith, accompanied by nine plates, and describing six new species from the Southwest; and notes on the interesting mound flora of Atchison county, Missouri, by B. F. Bush.

THE ROYAL ASTRONOMICAL SOCIETY.

AT the last meeting much of the interest of the evening centered in a comparison of two photographs of a well-known nebula—that near 15 Monocerotis—the one by the American astronomer, Professor E. E. Barnard, with a six-inch portrait lens, the other by Dr. Roberts, of Crowborough, with his 20-inch reflector. The exposures given and the ratio of aperture to size of image were practically the same in both cases. But the results were very different. Dr. Roberts' photograph showed a great amount of very delicate and beautiful detail in the nebula; Prof. Barnard's, when enlarged to the same scale, was of a much coarser character, but traced the nebula over a wider area. Dr. Roberts argued strongly against the reality of these faint extensions of the nebula shown in Professor Barnard's photograph, but the president showed, by a detailed comparison of the two photographs projected on the screen, that the contention was unfounded, and that the smaller instrument, though inferior to the larger for the exhibition of minute detail, had decidedly the advantage in the detection of faint nebulous masses. Another photograph by Dr. Roberts of the well-known crab nebula in Taurus also gave rise to some discussion, as it differed from the drawing made of the nebula by the late Lord Rosse in 1844. Mr. Chambers, however, pointed out that later visual observations had thrown doubt on the reality of some of the filaments shown in the sketch referred to. A paper from Professor Barnard gave a most convincing proof of variation having occurred in a nebula, that known as Hind's, in Taurus. Mr. Newall presented some recent observations of Phobos, the inner satellite of Mars, showing that the orbit of the satellite was distinctly elliptical, and the ephemeris some ten minutes in error. Mr. Stanley Williams contributed a very remarkable paper showing that spots in different longitudes of Saturn had different rotation periods. Mr. Wilson, of West Meath, described his

method of determining the heat radiation from the nucleus of a sun spot.—*London Times.*

GENERAL.

PRESIDENT CLEVELAND has extended the Civil Service Rules in the Department of Agriculture so as to include all officers and employees, excepting the Secretary and the Assistant Secretary of Agriculture and their private secretaries, the Chief of the Weather Bureau and his private secretary, the chief clerk of the department, and the laborers and charwomen.

IN congregation at Oxford a new statute has been promulgated, adding anthropology to the list of subjects in the Honor School of Natural Science.

A MEMORIAL tablet to John Couch Adams, the Cambridge astronomer and mathematician, was unveiled in Westminster on May 9th.

THE province of Ontario is to have a great reservation for the preservation of its animals and plants. The Algonquin Natural Park will comprise about a million acres of forest land. No hunting, trapping or destruction of animal life will be allowed within its precincts.—*American Naturalist.*

IT is announced that the sum of $250,000 or more has been given to the University of the City of New York for the purpose of erecting a central building on University Heights to contain the library, commencement hall, museum, and offices of administration. In accordance with the wish of the donor the name is not announced.

MAJ. J. W. POWELL is announced as lecturer on the 'History of Culture,' and Prof. Otis T. Mason as lecturer on the 'Origin of Culture,' in Columbian University.

ACCORDING to the accounts of Oxford University for 1894, recently presented to convocation, the revenue amounted to £63,760 and the payments to £64,390.

SIR GEORGE BUCHANAN, M. D., F. R. S., died on May 3d, at the age of 64. He was one of the first medical officers of health in London, having been appointed to St. Giles's in 1856. He originated methods of inquiry in sanitary matters not before attempted, working at the relation of overcrowding and other insanitary conditions of disease, at the prevention of smallpox, typhus fever, cholera and consumption, and originating a system of collecting statistical information of the public health of the district. He was chairman of The Royal Commission on Tuberculosis, which reported shortly before his death.

THE death is announced of Mr. Arthur Edward Durham, a member of the Council and late vice-president of the Royal College of Surgeons, of England. He was the author of *Sleeping and Dreaming* and *The Physiology of Sleep.*

FRANCIS P. HARPER announces *The Expeditions of Zebulon Montgomery Pike* to the headwaters of the Mississippi River, the interior parts of Louisiana, Mexico and Texas, in the years 1805–6–7, reprinted in full from the original Philadelphia edition of 1810, with full explanatory, geographical and scitific notes to the text, compiled from many unpublished sources of information and including the results of a canoe voyage of the editor to the sources of the Mississippi River, a new memior of Pike and an index to the whole by Dr. Elliott Coues.

AN Austrian expedition for polar research under the direction of M. Julius von Payer will start for Greenland in June, 1896.

AT the recent meeting of the Boston Scientific Society it was stated that Dr. Percival Lowell would observe the opposition of Mars in December, 1896, from a suitable location, not yet decided on. For this purpose a telescope of twenty-four inches' aperture has been ordered.

THE Spectacle Makers' Company recently presented Mr. W. H. M. Christie, Astronomer Royal of England, with its honorary freedom. The Master, in opening the ceremony, said that the spectacle makers claimed to be identified with those trades which, by the instruments they made, notably telescopes, microscopes, compasses, &c., enabled astronomers to pursue their studies and researches. In his reply, the Astronomer Royal said he could not but acknowledge what had been done for astronomy by opticians. It was true that a great deal was done by the early astronomers with very inefficient means. He might particularly mention Tycho Brahe, who, coming after the Greek, Chaldean and Jewish astronomers, besides others, had made great advances without the aid of the telescope. Astronomy and astrology continued to be one science up to the time when the telescope was invented.—*London Times.*

DR. MORRIS HENRY, a well known surgeon, died recently in New York at the age of seventy. He was the founder and editor of the *American Journal of Dermatology.*

THE May *Forum* contains an interesting article by Professor R. H. Thurston on *Our Debt to Inventors—Shall We Discharge Them?* Professor Thurston says: "The promotion of the arts and manufactures by suitably rewarding inventors and providing that they shall be permitted to collect profits, as in all other departments of business, as large as the business will yield, and in due proportion to the value to the country of the invention or discovery, is one of the most important features of an enlightened public policy; and it is the duty of every intelligent and patriotic citizen, and especially of every one in any manner connected with any department of engineering, of manufactures, or of the mechanic arts, to exert every power and to apply all his influence to promote the perfecting of the patent system, to increase the facilities of the Patent Office, and, especially, to insure the inventor of new and valuable devices a liberal period of possession of the products of his genius."

THE Microscopical Society of Washington held recently its annual exhibition. A large number of microscopical specimens and microscopes were exhibited.

PROFESSOR O. C. WHITMAN was announced to lecture on *The Utilities of Biology* at Mount Holyoke College on May 28th.

IN the Massachussetts Institute of Technology four instructors have been made assistant professors—Frederick S. Woods, Ph. D., in mathematics; Theodore Hough, Ph. D., in biology; Williom Z. Ripley, Ph. D., in sociology, and Richard W. Lodge in mining engineering. Samuel P. Milliken, Ph. D., was made instructor in organic chemistry, in place of Dr. Evans, resigned. The following assistants were raised to the position of instructors—W. Felton Brown, free-hand drawing; Simeon C. Keith, Jr., S. B., biology; Ervin Kenison, S. B., mechanical drawing; Frederick H. Keyes, S. B., mechanical engineering; Charles L. Norton, S. B., physics; Kilburn S. Sweet, S. B., civil engineering.

THE following instructors in the Sheffield Scientific School of Yale University have been made assistant professors: S. E. Barney, Jr., civil engineering; Dr. F. E. Beach, physics; Dr. W. A. Setchell, botany; Dr. Percy F. Smith, mathematics.

DR. O. S. STRONG has been appointed tutor in comparative neurology, and Dr. Hermann S. Davis assistant in astronomy, in Columbia College.

W. S. MATTHEW has been made assistant in the American Museum of Natural History.

IT is reported by telegraph from Naples that Mt. Vesuvius is in an unusually active state of eruption.

IT is stated that S. A. Andée's plan for reaching the North Pole by balloon under the auspices of the Royal Swedish Academy of Science will be assisted by a subscription of 30,000 kroners by King Oscar.

SCIENTIFIC JOURNALS.

THE AMERICAN CHEMICAL JOURNAL FOR MAY.

THE principal articles in this number are those containing reports of the investigations carried on by Remsen and others, on the chlorides of orthosulphobenzoic acid. Early in the investigation it was found that when the chloride was treated with aniline two products were obtained, which were most easily explained on the hypothesis that the chloride is a mixture of two isomeric chlorides corresponding to those of phthalic acid. This was afterwards shown to be the fact. Two chlorides were isolated and studied, and the results led to the conclusion that the so-called higher-melting chloride (melting point 76°) is the symmetrical one, having the formula

$$C_6H_4<^{CO\,Cl}_{SO_2Cl}$$

and the other, the lower-melting chloride (melting point 21.5°–22.5°), the unsymmetrical one, with the probable structure

$$C_6H_4<^{CCl_2}_{SO_2}>O$$

Both chlorides give ordinary orthosulphobenzoic acid when treated with water, but act differently when treated with ammonia, the symmetrical one forming benzoic sulphinide thus:

$$C_6H_4<^{CO\,Cl}_{SO_2Cl}+4NH_3=C_6H_4<^{CO}_{SO_2}>N.\,NH_4+2NH_4Cl$$

while the unsymmetrical one forms the ammonium salt of orthocyanbenzenesulphonic acid,

$$C_6H_4<^{CCl_2}_{SO_2}>O+4NH_3=C_6H_4<^{CN}_{SO_3NH_4}+2NH_4Cl.$$

As the unsymmetrical chloride is acted upon much more readily than the symmetrical one, it is only necessary to treat the mixture, under certain conditions, with ammonia, to obtain the symmetrical one in pure condition. The action of benzene and aluminum chloride, on the mixture or on the pure symmetrical chloride, leads to the formation of two products,

$$C_6H_4<^{CO\,C_6H_5}_{SO_2Cl} \text{ and } C_6H_4<^{COC_6H_5}_{SO_2C_6H_5}.$$

The latter breaks down when treated with potassium hydroxide, yielding diphenylsulphone and benzoic acid:

$$C_6H_4<^{COC_6H_5}_{SO_2C_6H_5}+KOH=C_6H_5SO_2.C_6H_5+C_6H_5\,COOK.$$

Besides these articles there are several shorter ones, one by Stone and Lotz showing the identity of the sugar called Agavose, with Sucrose, and one by Trevor on 'The Law of Mass Action.' Chase Palmer gives the results of an investigation of the chromates of thorium, and Cushman describes a method of separating copper and cadmium, which is more satisfactory than the method depending upon the precipitation of the cadmium in presence of the copper. He finds that cadmium sulphide is easily soluble in warm dilute hydrochloric acid in the presence of an excess of alkaline chlorides, and is easily precipitated, after filtering to remove the copper sulphide, which is unacted upon. There are also two very interesting reviews, by Professor Mallet, of the Reports on Chemical Industry at the World's Fair, prepared by the German and French chemical representatives.

J. ELLIOTT GILPIN.

THE BOTANICAL GAZETTE.

Issued May 18, 1895. 48 pp., 2 pl.

The Development of Botany in Germany during the Nineteenth Century: EDUARD STRASBURGER.

Professor Strasburger wrote an account of the progress of botany in Germany during the present century for the sumptuous work, *Die Deutschen Universitäten,* prepared under the direction of the imperial government for the educational department of the

World's Columbian Exposition at Chicago. This work is so costly and so inaccessible that Dr. Geo. J. Pierce has translated the paper into English, and, with the approval of Professor Strasburger and the editor of the work named, it is being published in the *Gazette*. It is particularly valuable in that it forms a supplement to Sachs's History of Botany, in a measure bringing it down to date. The conclusion will appear in the June number.

The Embryo-sac of Aster Novæ-Angliæ: CHAS. J. CHAMBERLAIN.

In this study of the structure of the embryo-sac of one of the highest spermaphytes the author shows that the formation of the secondary nucleus of the sac has no relation to a sexual process; comments on the remarkable uniformity in size of the nucleoli of the egg apparatus and endosperm; finds the number of the antipodal cells varying from 2 to 13 and the number of nuclei in each from 1 to 20 or more; and, most remarkable of all, announces that he has found an undoubted egg in the antipodal region.

Present Problems in the Anatomy, Morphology and Biology of the Cactaceæ: WM. F. GANONG.

Professor Ganong continues his account of these plants, in this concluding installment indicating the problems connected with the flowers; the relation of form-conditions to climate; the internal anatomy and its relation to external conditions; the newness of the family and its geographical distribution; and briefly discusses the bearing of the solution of these problems on adaptation and natural selection.

Some Recent Cell Literature: J. E. HUMPHREY.

At the request of the editors Dr. Humphrey has prepared a review of recent cell literature and a summary of our present knowledge of the nucleus and centrospheres.

In *Briefer Articles* DR. C. R. BARNES notes the retention of vitality in the spores of *Marsilia quadrifolia*, whose sporocarps had been continuously for nearly three years in 95 per cent. alcohol; MR. G. E. DAVENPORT adds stations for his new New England species, *Aspidium simulatum*, which is likely to be in many collections under the name *A. Thelypteris* or *A. Noveboracense;* DR. J. C. ARTHUR condenses a biographical sketch of the late Dr. Joseph Schrœter; and MISS ALICE E. KEENER notes that the peculiar protection of the nectar gland in *Collinsia bicolor* by the free bearded tips of the wings of the filaments is a good diagnostic character which occurs in no other Collinsia except (less strikingly) in *C. franciscana*. The *Editorial* is on the recent transfer of the National Herbarium to the care of the Smithsonian Institution. In *Current Literature* appear reviews of 'Field, Forest and Garden Botany;' the second edition of Spalding's 'Introduction to Botany;' the 'Bushberg Catalogue and Grape Growers' Manual;' together with notices of several short papers. The number closes with four pages of *Notes and News*.

THE PSYCHOLOGICAL REVIEW.

The Psychological Review for May is devoted to experimental work. The first article is a 'Preliminary Report on Imitation' by Professor Josiah Royce. He reports the first-fruits of an attempt to submit the imitative functions to an experimental test by giving adult subjects series of rhythmical sounds, such as taps by an electric hammer, which it is their task to reproduce exactly in rhythm and sequence by second series of taps. He promises in a future communication to report on the results, which he finds sufficiently encouraging. The main body of this paper is further devoted to an acute discussion of the definition of imitation and the demarcation of the truly imitative functions. A large part of the number is taken up by a series of 'Studies from the Princeton Psychological Laboratory,' by J. Mark Baldwin, H. C. Warren and W. J. Shaw,

five papers in all, giving the output of this new laboratory for the first year. Among the results of most interest reported in these studies may be mentioned the following: The relative falling off in the accuracy of memory after intervals of 10, 20 and 40 minutes is shown by curves, the thing remembered being square magnitudes exhibited to large classes of students. A contrast effect of squares of different sizes shown simultaneously to the eye was discovered, as is reported in a detailed research. It was found that the distance between two squares of different sizes can not be accurately bisected by the eye. There is a constant error in judgment toward the smaller square, whether the two be arranged horizontally or vertically. And the error in finding the midpoint increases as the disproportion between the two squares becomes greater, but always in the same direction. This was tested by different methods, one of which was designed to rule out the effect of eye-movements. Another 'Study,' on 'Types of Reaction,' reports two cases of reagents who give shorter 'sensory' than 'motor' reactions. Professor Baldwin, the author of this paper, accounts for these cases, and earlier ones reported by Cattell and Flournoy, on the general view of mental types founded on recent cases of aphasia. 'Shorter Contributions,' by H. C. Wood, on the 'Haunted Swing Illusion,' and H. R. Marshall on 'Heat Sensations in the Teeth,' make up the rest of the articles. The usual section on 'Psychological Literature' is full and varied. Many readers will be interested by the review in this section of Nordau's book on *Degeneration* by Professor William James, who also reviews several other recent works on 'Degeneration and Genius.'

NEW BOOKS.

Canyons of the Colorado. J. W. POWELL. With many illustrations. Meadville Flood and Vincent. 40. Pp. 400.

A Brief Descriptive Geography of the Empire State. C. W. BARDEEN. Syracuse, N. Y., C. W. Bardeen. Pp. viii + 126. 75 cts.

Engineering Education. Proceedings of the Second Annual Meeting of the Society for the Promotion of Engineering Education, Vol. II. Edited by GEO. F. SWAIN, IRA O. BAKER, J. B. JOHNSON. Columbia, Mo. 1895. Pp. vi + 292. $2.50.

Birdcraft. MABEL OSGOOD WRIGHT. New York and London, Macmillan & Co. 1895. Pp. 317. $3.00

Familiar Flowers of Field and Garden. F. SCHUYLER MATHEWS. New York, D. Appleton & Co. 1895. Pp. vii+308. $1.75.

Articles and Discussions on the Labor Question. WHEELBARROW. Chicago, Open Court Publishing Co. 1895. Pp. 303. 35 cts.

Crystallography. N. STORY-MASKELYNE. Oxford, The Clarendon Press, New York, Macmillan & Co. Pp. xii+521. $3.50.

Official Year-Book of the Scientific and Learned Societies of Great Britain and Ireland. London, Charles Griffin & Co., limited. 1895. Pp. iv+ 254. 7s. 6d.

Complete Geography. ALEX. EVERETT FRYE. Boston and London, Ginn & Co. 1895. iv+175.

The Horticulturalists' Rule-book. L. H. BAILEY. New York and London, Macmillan & Co. 1895. Pp. ix+302. 75 cts.

The Diseases of Personality. TH. RIBOT. Authorized translation. Second revised edition. Chicago, The Open Court Publishing Co. 1895. Pp. viii+163. Cloth, 75 cts; paper, 25 cts.

Major James Rennell and the Rise of Modern English Geography. CLEMENT R. MARKHAM. New York, Macmillan & Co. 1895. Pp. vii+ 232. $1.25.